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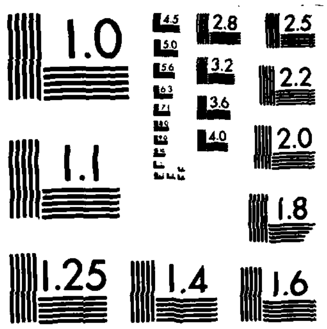

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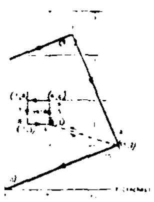

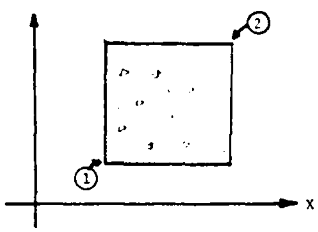

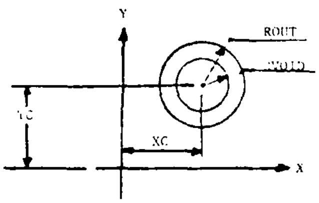

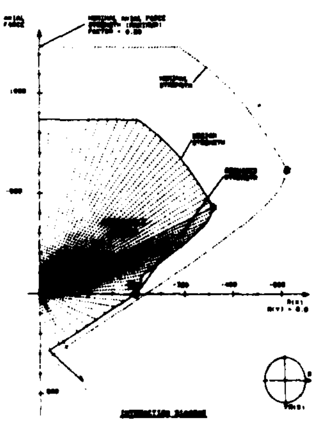

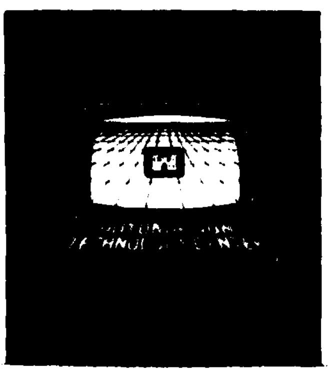

INSTRUCTION REPORT K-84-10

USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS

Report 1

CONCRETE GENERAL STRENGTH INVESTIGATION (CGSI)

by

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Michael E. George

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PO Box 631
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September 1984
Report 1 of a Series

Prepared for US Army Engineer Division
Lower Mississippi Valley
Vicksburg, Mississippi 39180

Monitored by Automation Technology Center
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Instruction Report K-84-10	2. GOVT ACCESSION NO. A156 392	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS; Report 1, CONCRETE GENERAL STRENGTH INVESTIGATION (CGSI)		5. TYPE OF REPORT & PERIOD COVERED Report 1 of a series 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William A. Price III Michael D. Davister Michael E. George		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Automation Technology Center US Army Engineer Waterways Experiment Station PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Engineer Division Lower Mississippi Valley Vicksburg, Mississippi 39180		12. REPORT DATE September 1984 13. NUMBER OF PAGES 46
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) US Army Engineer Waterways Experiment Station Automation Technology Center PO Box 631, Vicksburg, Mississippi 39180-0631		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Columns, concrete--testing (LC)
Concrete beams--testing (LC)
CGSI (Computer program) (LC)
Flexural strength (concrete) (WES)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Strength investigation on nonhydraulic beams and columns defines the program described in this user's guide. The program, obtained from another agency and adapted to Corps of Engineers usage, applies a fundamental theory and, therefore, is not code-dependent.

This program, Concrete General Strength Investigation (CGSI), and another program, Portland Cement Association's PCAUC, complement each other in their capabilities and their equipment requirements.

(Continued)

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20. ABSTRACT (Continued).

Program CGSI investigates the strength of a reinforced concrete member with cross sections subjected to combined axial load and biaxial bending. Results are presented in graphical form.

Program PCAUC may be used to design and/or investigate reinforced concrete compression members. There is no graphics output for results from this program.

Neither of the programs considers shear.

Additional keywords: FORTRAN; output; Input files;

Accession For
NTIS GRA&I ☒
DTIC TAB ☐
Unannounced ☐
Justification

By
Distribution/
Availability Codes

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PROGRAM INFORMATION

Description of Program PCAUC

PCAUC, called X0062 in the Conversationally Oriented Real-Time Programming System (CORPS), is a program to design and/or investigate rectangular or circular concrete columns conforming with the strength theory contained in ACI Code 318. The program will also investigate the strength of rectangular beams and is restricted to nonhydraulic structures.

Coding and Data Format

PCAUC is written in FORTRAN and is operational on the following systems:

a. Division office Honeywell DPS computers.

b. District office Harris 500 computers.

c. Cybernet contract service.

Data for PCAUC may be in a previously prepared data file or entered interactively. Output from the program is directly to the user's time-sharing terminal and it utilizes a printing terminal.

How to Use Program PCAUC

Directions for accessing the program on each of the three systems is provided below. It is assumed that the user can prepare the terminal equipment and sign on the appropriate system before attempting to use the program. In the example initiation of execution commands below, all user responses are underlined and each should be followed by a carriage return. The acronym XOONN should be replaced by X0062 for PCAUC.

Honeywell Systems

After the user has signed on the system, the system command FORT brings the user to the level to execute the program. Next, the user issues the run command.

RUN WESLIB/CORPS/XØØNN, R

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example initiation of execution is as follows, assuming a data file has previously been prepared:

```
HIS TIMESHARING ON Ø3/Ø4/81 AT 13.3Ø1 CHANNEL 5647
USER ID - RØKACASECON
PASSWORD - [redacted]
*FORT
*RUN WESLIB/CORPS/XØØNN,R
```

CYBERNET System

The log-on procedure is followed by a call to the CORPS procedure file

OLD,CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in the command

BEGIN,,CORPS,XØØNN

to initiate execution of the program. An example is:

```
84/12/05.  16.41.ØØ.  AC2F5DA
EASTERN CYBERNET CENTER SN9Ø4 NOS   1.4/531.669/2ØAD
FAMILY:  KOE
USER NAME:  CERØXX
PASSWORD -
XXXXXXXX
TERMINAL:      23, NAMIAF
RECOVER/CHARGE:  CHARGE, CEROEGC, CERØXX
$CHARGE
12.49.Ø7.  WARNING (various information messages may appear here)

11/29 FOR IMPORTANT INFO TYPE EXPLAIN, WARNING. (various information messages
may appear here)
OLD,CORPS/UN=CECELB
/BEGIN,,CORPS,XØØNN
```

Harris 500 System

The log-on procedure is followed by a call to the program executable file, with the user typing the asterisk and file description.

*CORPS,XØØNN

to initiate execution of the program. An example is

```
"ACOE-ABLESVILLE (H500 V3.1)"
ENTER SIGN-ON
1234ABC,STRUCT

**GOOD MORNING STRUCTURES, IT'S 7 DEC 84 08:33:12
AED HARRIS 500 OPERATING HOURS 0700-1800 M-S
*CORPS,XØØNN
```

How to Use CORPS

The CORPS system contains many other useful programs which may be catalogued

from CORPS by use of the LIST command. The execute command for CORPS on Honeywell systems is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP) *?LIST
```

on the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
BEGIN,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

and on the Harris system, the commands are:

```
*CORPS
ARE YOU USING A PRINTER TERMINAL OR CRT?
ENTER P OR C
C
CORPS SYSTEM COMMANDS:
BRIEF - LIST EXPLANATION OF A PROGRAM.
EXECUTE - RUN A CORPS PROGRAM
LIST - LIST THE AVAILABLE CORPS PROGRAMS.
STOP - EXIT FROM CORPS SYSTEM MACRO.
HELP - HELP AND EXPLANATION OF CORPS
       SYSTEM AND THE RUNNING OF ITS MACRO.

NOTE:  COMMANDS MAY BE ABBREVIATED TO THE
       FIRST LETTER OF THE COMMAND.

ENTER COMMAND(BRIEF,EXECUTE,LIST,HELP,STOP):
S
STOP
```

PROGRAM INFORMATION

Description of Program CGSI

CGSI, called X0061 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library, is a program designed to perform an investigation analysis, according to strength theory, of a reinforced concrete beam or column. This is in compliance with the ACI Code 318. Corps of Engineers usage is restricted to nonhydraulic structures.

Coding and Data Format

CGSI is written in FORTRAN and is operational on the following systems:

a. Division office Honeywell DPS computers.

b. District office Harris 500 computers.

c. Cybernet contract service.

Data for CGSI must be in a previously prepared data file with line numbers. Output from the program is directed to the user's time-sharing terminal which must be a Tektronix 4014 graphics terminal.

How to Use Program CGSI

Directions for accessing the program on each of the three systems is provided below. It is assumed that the user can prepare the terminal equipment and sign on the appropriate system before attempting to use the program. In the example initiation of execution commands below, all user responses are underlined and each should be followed by a carriage return.

Honeywell Systems

After the user has signed on the system, the system command FORT brings the user to the level to execute the program. Next, the user issues the run command.

RUN WESLIB/CORPS/XØØ61

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example initiation of execution is as follows, assuming a data file has previously been prepared:

```
HIS TIMESHARING ON Ø3/Ø4/81 AT 13.3Ø1 CHANNEL 5647
USER ID - RØKACASECON
PASSWORD - [redacted]
*FORT
*RUN WESLIB/CORPS/XØØ61,R
```

CYBERNET System

The log-on procedure is followed by a call to the CORPS procedure file

OLD,CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in the command

BEGIN,,CORPS,XØØNN

to initiate execution of the program. An example is:

```
84/12/05.  16.41.ØØ.  AC2F5DA
EASTERN CYBERNET CENTER SN9Ø4 NOS   1.4/531.669/2ØAD
FAMILY:  KOE
USER NAME:  CERØXX
PASSWORD -
XXXXXXXX
TERMINAL:      23, NAMIAF
RECOVER/CHARGE:  CHARGE, CEROEGC, CERØXX
$CHARGE
12.49.Ø7.  WARNING (various information messages may appear here)

11/29 FOR IMPORTANT INFO TYPE EXPLAIN, WARNING. (various information messages
may appear here)
OLD,CORPS/UN=CECELB
/BEGIN,,CORPS,XØØ61
```

Harris 500 System

The log-on procedure is followed by a call to the program executable file, with the user typing the asterisk and file description.

*CORPS,XØØ61

to initiate execution of the program. An example is

```
"ACOE-ABLESVILLE (H500 V3.1)"
ENTER SIGN-ON
1234ABC,STRUCT

**GOOD MORNING STRUCTURES, IT'S 7 DEC 84 08:33:12
AED HARRIS 500 OPERATING HOURS 0700-1800 M-S
*CORPS,XØØ61
```

How to Use CORPS

The CORPS system contains many other useful programs which may be catalogued

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ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP) *?LIST
```

on the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
BEGIN,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

and on the Harris system, the commands are:

```
*CORPS
ARE YOU USING A PRINTER TERMINAL OR CRT?
ENTER P OR C
C
CORPS SYSTEM COMMANDS:
BRIEF - LIST EXPLANATION OF A PROGRAM.
EXECUTE - RUN A CORPS PROGRAM
LIST - LIST THE AVAILABLE CORPS PROGRAMS.
STOP - EXIT FROM CORPS SYSTEM MACRO.
HELP - HELP AND EXPLANATION OF CORPS
       SYSTEM AND THE RUNNING OF ITS MACRO.

NOTE:  COMMANDS MAY BE ABBREVIATED TO THE
       FIRST LETTER OF THE COMMAND.

ENTER COMMAND(BRIEF,EXECUTE,LIST,HELP,STOP):
S
STOP
```

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM	PROGRAM NO.
CGSI--Concrete General Strength Investigation	713-F3-R0061

PREPARING AGENCY

USAEWES, ADP Center, Computer-Aided Design Group

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM	
		PHASE	STAGE
Michael D. Davister, USBR; adapted by William A. Price III, WESKD, and Michael E. George, WESKS	June 1982		

A. PURPOSE OF PROGRAM

Investigation of a strength of reinforced concrete sections subjected to flexure or axial force + biaxial flexure. Basic use of the program conforms to ACI 318-83.

The Concrete outline is general, as defined by not more than 98 corners. The concrete section may have voids. Reinforcing steel may be enclosed by ties or spirals, grouped into not more than 30 rows of one or more bars each. Sections with no reinforcement may be investigated.

B. PROGRAM SPECIFICATIONS

Written in FORTRAN IV for Honeywell level 66 with GCS, adaptable to CDC FORTRAN IV with PLOT 10 graphics system.

C. METHODS

Interaction diagrams are plotted for the input section, keeping a constant M_x/M_y ratio. Two diagrams are plotted, one for the nominal strength (M_n), the other for the design strength (i.e., $d\ M_n$), where d is from ACI 381-77 code. The location of the applied load is plotted. Maximum actual strains and a balanced strains condition are shown for concrete and steel (if steel is present).

D. EQUIPMENT DETAILS

Honeywell level 66 FORTRAN with the Graphics Compatibility System. The program loads, with data file open, in 39 1024-word blocks of core memory.

Program executes interactively from a Tektronix 4014 graphics terminal. Alphanumeric terminals are not satisfactory.

E. INPUT-OUTPUT

Input is from a data file; line numbers are optional.

Output is to a Tektronix 4014 with hard copy unit. All output is automatically directed to hard copy (the terminal may be unattended during program execution).

F. ADDITIONAL REMARKS

1. The program was adapted from the US Bureau of Reclamation program G4BIAXU.
2. Call William A. Price at the WES Automation Technology Center for more information.

WES FORM 1 JUL 80 2205 REPLACES ENG FORM 2883 WHICH IS OBSOLETE.

PREFACE

This user's guide describes a computer program for strength investigation of nonhydraulic beams and columns. It is not code-dependent because of the fundamental theory. Program CGSI was obtained from another government agency and adapted to Corps of Engineers usage.

The work in converting this program and preparing the final user's guide was accomplished with funds provided to the US Army Engineer Waterways Experiment Station (WES) by the Lower Mississippi Valley Division (LMVD) of the Corps of Engineers. This is part of a project to establish a library of available programs for strength design of concrete throughout LMVD.

Program CGSI (CORPS X0061) was adapted from the US Bureau of Reclamation's (USBR) program G4BIAXU, written by Michael D. Davister, formerly with the USBR. It was revised to conform to Corps of Engineers usage by Messrs. William A. Price III, Chief, Engineering Applications Group (EAG), Scientific and Engineering Applications Division (SEAD), Automation Technology Center (ATC), and Michael E. George, formerly of the Micro and Computer Science Group, WES, now with the LMVD office of the Automatic Data Processing Coordinator.

The work was coordinated by Mr. Price under the direction of Mr. Paul K. Senter, Research Group, SEAD, and supervision of Dr. N. Radhakrishnan, Chief, ATC. Mr. Victor M. Agostinelli was the point of contact in LMVD.

The Commanders and Directors of WES during the period of this work and publication of this report were COL Tilford C. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees	0.01745329	radians
inches	0.0254	metres
kips	4448.222	newtons
kip-feet	1355.818	newton-metres
pounds (force) per square inch	6894.757	pascals
square inches	0.00064516	square metres

USER'S GUIDE: A COMPUTER PROGRAM FOR STRENGTH ANALYSIS OF NONHYDRAULIC CONCRETE STRUCTURAL ELEMENTS

CONCRETE GENERAL STRENGTH INVESTIGATION (CGSI)

PART I: INTRODUCTION

General Description of Program

1. Computer program CGSI investigates the strength of a concrete beam/column structural member subjected to multiple load cases consisting of axial force and biaxial flexure. The member may have any shape cross section, with any arrangement of reinforcing steel, or be unreinforced. It follows the strength theory described in Chapter 10 of ACI Code 318-83 for shallow beams and short columns. Written in Fortran IV and requiring a time-sharing graphics terminal, this program does not consider the effects of shear.

Comparison with Other Strength-Theory Programs

2. This program is one of a pair, both following the same basic theory and ACI Code references. The other program is PCAUC, the Portland Cement Association's "Strength Design of Reinforced Concrete Column Sections," described in detail in Report 2 of this series. The two programs, CGSI (X0061) and PCAUC (X0062), complement each other to furnish the capabilities listed below. Both programs will analyze for loadings including axial load with superimposed biaxial flexure, according to Section 10.2 of American Concrete Institute (ACI) Code 318-83. Neither of these programs considers shear. Part II of this report gives full theoretical and input guide information of program CGSI.

Member-type criteria

3. Beams are defined as having any reinforcing steel pattern, symmetrical or not, with a tensile failure. Program CGSI will analyze unreinforced sections as well. Both programs will investigate beams for percentage of ultimate capacity, along with other information relating to actual strains, percentage of balanced reinforcement, etc., and can furnish an interaction diagram. They each have simplified input for rectangular and circular

cross sections; CGSI also provides for cross sections described by a series of consecutive line segments connecting the corners of an irregular polygon. Neither program will design beams nor investigate shear strengths.

4. Columns are defined as having a reinforcement pattern that is separately symmetrical about both axes and has a compression failure. Both programs provide for the strength of the cross section to be calculated according to ACI 318-83, Section 10.3.5.1 for spiral columns or Section 10.3.5.2 for tied columns, using the same ratio of M_x to M_y as the applied loading. Program CGSI will also investigate columns with unsymmetric reinforcement or no reinforcement. Each program furnishes the percentage of capacity used, interaction diagram values, and actual strains when investigating. PCAUC will design rectangular or circular short columns; CGSI will not. CGSI will, however, investigate columns with any cross section.

Analysis procedure

5. The two programs follow the same strength theory listed in Sections 10.2.2 through 10.2.6 and 10.3 of ACI Code 318-83, for shallow beams and short columns.

6. Program CGSI uses the trapezoidal shape described in paragraph 14 and program PCAUC uses a parabolic relationship between concrete compressive stress distribution and concrete strain, both in accordance with Section 10.2.6 of ACI 318-83. In analyzing rectangular shapes, CGSI predicts moment strengths.

Force/moment interaction

7. Both programs first compute the theoretical strength of a member on the basis of the strengths of the materials, then reduce the theoretical strength to the design strength by multiplying by the capacity reduction factor as described in Section 9.3 of ACI Code 318-83. The interaction diagram values used to obtain the percentage of design strength of the factored applied load are arrived at by considering a three-dimensional interaction surface. This surface is cut by a P-M plane oriented to the same ratio of M_x to M_y as the applied load. This planar diagram is displayed by program CGSI and optionally printed in tabular form by program PCAUC.

Equipment requirements

8. Equipment requirements are the same in some areas for the two programs but vary in others, as listed in the following paragraphs.

a. CGSI (X0061) will run only on a Tektronix 4014 graphics time-sharing terminal. The entire program will run unattended after

the data file has been named. Hard copies are made automatically so that nothing is lost.

b. PCAUC (X0062) will run on any terminal. While there are no graphics displays, the printed output can include an optional table of interaction diagram values for the user to plot outside the program.

PART II: DETAILED USER'S GUIDE FOR PROGRAM CGSI (X0061)

Purpose and Capabilities of Program

9. Program CGSI investigates the strength of a reinforced concrete member with cross sections subjected to combined axial load and biaxial bending. Results are presented in graphical form. The analysis procedure conforms to ACI Code 318-83.

10. The cross section is described by a polygon with as many as 98 corners; voids are permitted. Reinforcement, if present, is grouped in no more than 30 rows. Each row consists of any number of bars; rows may have any orientation.

11. Multiple load cases are permitted in one problem and each load case may be composed of an unlimited number of additive loads. An unlimited number of different problems may be placed in sequence in one data file. Once started, the program runs unattended.

12. The program requires a Tektronix 4014 graphics terminal. Hard copies are automatically made of all output.

Program Limitations

13. The program functions are limited by the following:

a. No more than 98 sides to the polygon describing a cross section.

b. No more than 30 rows of reinforcing bars.

c. Shear is not considered.

Analysis Procedure Overview

Interpretation of the process

14. The iterative process described by Chiu and Pabarcius* is used to determine the orientation and location of the neutral axis. The assumed strain distribution, stress distribution in the concrete, and stress distribution in the steel is shown in the diagram on page 8. The following items are of note in interpreting the process:

a. Strain in steel and concrete is linearly proportional to the distance from the neutral axis.

---

* Chiu, K. H., and Pabarcius, A. 1958 (Dec). "Biaxially Loaded Reinforced Concrete Columns, Journal of the Structural Division, American Society of Civil Engineers, Vol 84, No. ST8, Proceedings Paper 1865, pp 1-27.

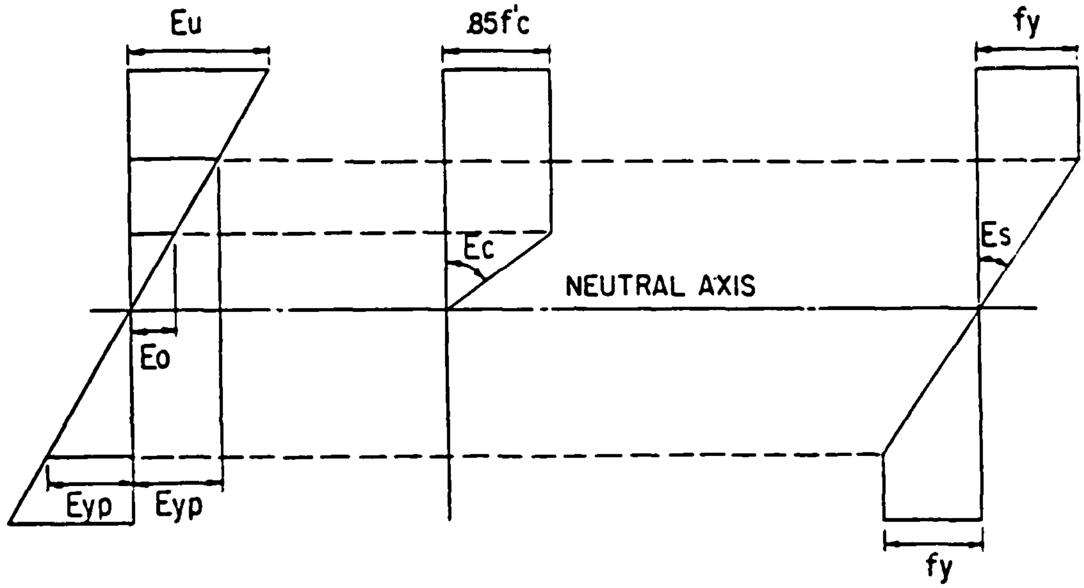
b. Balanced condition is attained when the extreme compression strain is equal to the "e_{max}" value shown in Figure 2* of the output and the extreme reinforcement strain is equal to the ratio of the f_y/E_s values shown in Figure 1 of the output.

c. Reinforcement stress below f_y is equal to E_s times the strain in the steel.

d. The concrete stress block at the balanced condition is assumed to be a trapezoid with a maximum stress of $0.85\ f'_c$.

e. Tensile strength of the concrete is neglected.

f. Unreinforced sections are considered, limited to no tension anywhere.



STRAIN DISTRIBUTION IN REINFORCED CONCRETE — STRESS DISTRIBUTION IN CONCRETE — STRESS DISTRIBUTION IN REINFORCING STEEL

Eu=ULTIMATE STRAIN OF CONCRETE=.003
Eo=MAXIMUM STRAIN AT WHICH CONCRETE REMAINS ELASTIC
Eyp=YIELD POINT STRAIN OF STEEL
f'c=28-DAY STRENGTH OF CONCRETE
Ec=CONCRETE MODULUS OF ELASTICITY
fy=YIELD POINT STRESS OF STEEL
Es=STEEL MODULUS OF ELASTICITY

This diagram is copied from Figure A-P2BAXUS-6 in the USBR documentation for program G4BIAUX.

---

* References to a figure number in this report refer to the computer printout. The results of a program execution are arranged in figures, one per Tektronix 4014 screen full. Figure 1 always shows a summary of the input data, Figure 2 always shows the results of analyzing one load case (Figure 2.1 will be the first load case, Figure 2.2 the second load case, etc).

Source

15. For further information, the documentation for US Bureau of Reclamation (USBR) program G4BIAXU from which program CGSI was adapted is available on request by contacting Mr. William A. Price, Waterways Experiment Station, telephone (601)634-3645, FTS 542-3645.

Input Guide

General instructions

16. Required order. The lines of data in the data file must be entered in a specified order. These lines of data are separated into different sections. The sections are named in the data file and will be input as described in the following paragraphs. Some of the sections are optional and may be omitted. The data items in a section must be in the order shown.

17. Separation between data items. Data items on a line must be separated by commas. From one to three blanks may be inserted after a comma to make it more apparent. A blank is not recognized as a separation. No more than three consecutive blanks should be used at any one place unless the rest of that line is to be ignored. Floating-point numbers that are whole numbers need not have a decimal point and integer numbers must not have a decimal.

18. Nonnumeric data. Each section of the data file, except the first line of the data file which contains the user's name, begins with a section name word (Member, Section, Materials, etc.). Only the first three characters of a section name word need to be entered. Section name words are shown in this user's guide in all capital letters.

19. Multiple problems. Several problems may be stacked in one data file. This is described in the user's guide at the points where additional problems may be started.

Data preparation

20. USER'S NAME section. The first line of the data file is used for user identification. This will be printed after the words "DATA PREPARED BY --" in the upper left corner of Figure 1 of the output. A corresponding Figure 1 can be found following each example in the text on pages 25, 31, 37, and 43. There is no name word for this section. The number of characters in the user's name must not exceed 30.

21. MEMBER section. This section must be set up as follows:

MEMBER, name

where

MEMBER = data section name word

name = identification of concrete member, 10 characters maximum. This will be printed in the lower right corner of all pages of the output, after the word "MEMBER"

Note: Subsequent problems may begin with this section if the member name is to change.

22. SECTION section. This section will be arranged as shown below:

SECTION, name

where

SECTION = data section name word

name = identification of particular cross section along the concrete member, 10 characters maximum. This will be printed in the lower right corner of all pages of the output, after the word "SECTION"

Note: Subsequent problems may begin with this section if the member name is not to change.

23. MATERIALS section. This section is optional, used only if its data values are to start out being different from the default values or to change from the previous problem in the data file.

MATERIALS, f'_c, f_y

where

MATERIALS = data section name word

f'_c = concrete ultimate strength, psi
Default value = 3,000.0

f_y = reinforcing steel yield strength, psi
Default value = 60,000.0

24. SPIRAL section. This will change the axial load capacity from the ACI Code 318-17 paragraph 10.3.5.2 factor of 0.80 to the paragraph 10.3.5.1 factor of 0.85. There is no provision to restore the initial value of 0.8, so program runs with multiple problems should have the spiral columns after all of the tied columns. The data section consists of the single word data section name only.

SPIRAL

where

SPIRAL = data section name word

25. DIMENSIONS section. This section is optional, used only if its

data value is to start out being different from the default value or to change from the previous problem in the data file.

DIMENSION, units

where

DIMENSION = data section name word

units = IN for inches or FT for feet, for all coordinate locations in the following data sections: POINTS, RECTANGLE, CIRCLE, REINFORCE, and LOAD. Default = IN

26. Concrete outline description section. The following section is outlined by lines, points, and cross section in the paragraphs below.

a. Generalized cross section. The concrete cross section is described by a series of coordinate points at the corners joining straight line sections. The points are in an order that puts concrete to the right, air to the left. Thus the order is clockwise around the outside of the cross section and counterclockwise around any voids. The last point must lie on the first point, so that a rectangle would be described by five points. A maximum of 99 points describing a maximum of 98 sides to the polygon may be used. This section takes at least two lines, probably more.

(1) First line of section:

POINTS, np

where

POINTS = data section name word

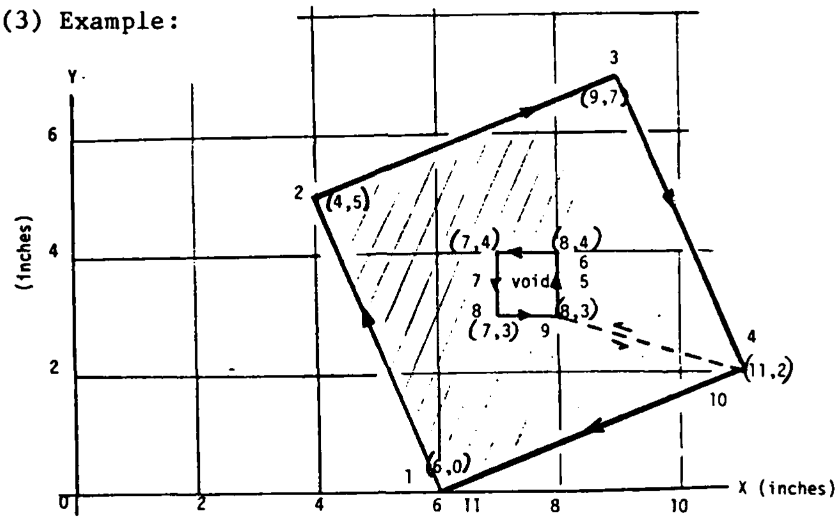
np = how many points are to be used, includes the last point that falls on top of the first point. Not over 99, integer

(2) Second and following lines of section:

$$x_1, y_1, x_2, y_2, \ldots x_n, y_n, \ldots, x_{np}, y_{np}$$

use as many lines as are necessary, do not end intermediate lines with commas. There is no set number of coordinate points on a line. The units are set by the DIMENSION data section.

(3) Example:




```
POINTS, 11
6,0, 4,5, 9,7, 11,2, 8,3
8,4, 7,4, 7,3, 8,3, 11,2
6,0
```

b. Rectangular cross section. A solid rectangular cross section can be described with a single-line alternate to the POINTS description. The rectangle must be oriented parallel to the axes and lie in the positive-x, positive-y quadrant. Point 1 must be closer to the coordinate origin than point 2. The table of coordinates of section points in Figure 1 of the output will show five points labeled 1 through 5, with points 1 and 5 located at corner 1 and point 3 located at corner 2. (A Figure 1, as applied to each example, is found on pages 25, 31, 37, and 43.)

(1) Data section format

RECTANGLE, X1, Y1, X2, Y2

where

RECTANGLE = data section name word

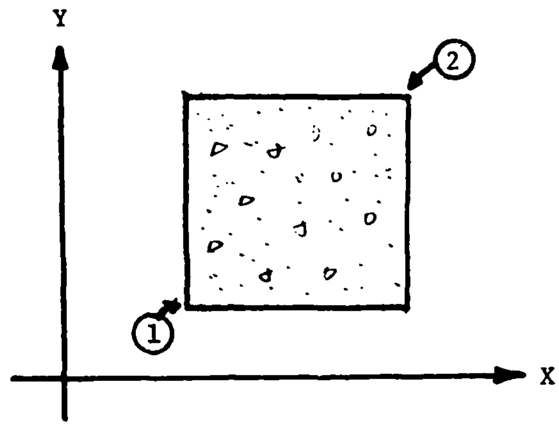
X1 = X-coordinate of corner 1, less than X2

Y1 = Y-coordinate of corner 1, less than Y2

X2 = X-coordinate of corner 2, diagonally opposite point 1

Y2 = Y-coordinate of corner 2.

(2) Example:



c. <u>Circular cross section.</u> A circular cross section, with or without an optional concentric void, can be described with a single-line alternate to the POINTS description. The circle must lie entirely in the positive-X, positive-Y quadrant. The table of coordinates of section points in Figure 1 of the output will show closely spaced (15 deg) points arranged around the outer and (optional) void circles. (Figure 1, shown with each example, are on pages 25, 31, 37, and 43.) Points 1 and 25 will be at the "top" (largest Y-coordinate) of the outer circle; optional points 26 and 50 will be at the "top" of the void circle. Point 51, if shown, will coincide with point 1.

(1) Data section format

CIRCLE, ROUT, RVOID, XC, YC

where

CIRCLE = data section name word

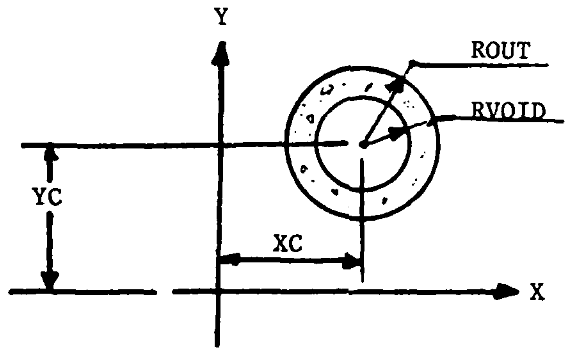
ROUT = outside radius of circular cross section

RVOID = radius of concentric void, zero if no void

XC = X-coordinate of center

YC = Y-coordinate of center

(2) Example:



REINFORCEMENT section

27. The reinforcement data section is used only if there is reinforcement in the cross section; the program will analyze unreinforced sections (sample problem 3). Reinforcement is arranged in rows of one or more bars each; all of the bars in any one row must be evenly spaced and of the same size. Up to 30 rows may be described. A row may be oriented in any direction.

a. First line of section:

REINFORCE, nr

where

REINFORCE = data section name word

nr = how many lines of data will follow, one line of data for each row of reinforcement, integer, 30 max.

b. Following lines in section:

nb, abar, x_1, y_1, x_2, y_2

where

nb = how many bars are in the row, integer

abar = cross-sectional area of one bar, sq in.

x_1 = x-coordinate of end one of the row*

y_1 = y-coordinate of end one of the row*

x_2 = x-coordinate of end two of row, ignored if nb = 1 (but a value must be shown)*

y_2 = y-coordinate of end two of row, ignored if nb = 1 (but a value must be shown)*

---

* Units are determined by the DIMENSION data section (default = IN).

A77 section

28. This section contains only the single-data section name word:

A77

where the line tells the program to prepare to analyze the loading-data sections to follow, in accordance with ACI Code 318-77. The data file may then go directly to EXIT if all that is wanted is a points and reinforcing data check (Figure 1 of output). These figures are shown with each example on pages 25, 31, 37, and 43.

LOAD case sections

29. An unlimited number of load cases can be analyzed. Simply repeat this data section once per load case.

a. First line of data section:

LOAD, load case name, nP

where

LOAD = data section name word

load case name = alphanumeric load case name, 10 characters max.

nP = how many load sets will be described in the load set is one combination of x-axis and y-axis moments, and an axial load at a given location. These sets will be superimposed by the program to form a single set to be investigated. No limit on how many load sets per load case

b. Following lines of data section:

m_x, m_y, force, x_{force}, y_{force}

where

m_x = factored moment about x-axis, kip-ft. A positive value causes tension in quadrants 1 and 2 and compression in quadrants 3 and 4. The program will calculate the additional moment due to the concentrated force and its location

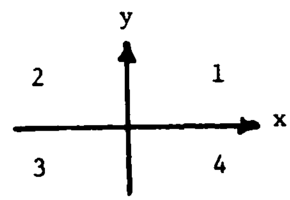
m_y = factored moment about y-axis, kip-ft. A positive value causes tension in quadrants 2 and 3 and compression in quadrants 1 and 4. The program will calculate additional moment due to the force and its location

force = factored concentrated axial force, kips. A positive value causes tension. A value must be given, even if it is zero.

x_{force} = x-coordinate of location of the concentrated force. A value must be given.*

y_{force} = y-coordinate of location of the concentrated force. A value must be given.*

There is no limit to how many load set data lines may be used in any one load case section. The sets will be summed and analyzed as a combined, single set of M_x , M_y , and a force acting on the section.



Quadrant Locations

After all load cases

30. There are three options at this point.

a. Another cross section in the same number:

Repeat the data-section sequence, starting with the SECTION data section (paragraph 22).

b. Another member (completely new problem):

Repeat the data-section sequence, starting with the MEMBER data section (paragraph 21).

c. No more data:

End the data file with a line containing the single word

EXIT

The terminal will sound several beeps to signal run completion.

Input Guide Summary

31. Data preparation rules:

a. Words shown in all capital letters are data-section names; using capitals, enter at least the first 3 letters.

b. Words shown in lower case letters are names of variables; enter the actual value.

c. Separate all items with one comma, followed by not more than three blanks.

---

* Units are determined by the DIMENSION data section (default = IN).

d. The first item on each line must be a line number.

(1) The first line of a data file contains the user's name (30 characters max.).

(2) MEMBER, member (10 characters max.) (new problem may start here)

(3) SECTION, section (10 characters max.) (new problem may start here)

(4) MATERIALS, f'_c, fy (psi) (optional, defaults are 3,000, 48,000)

(5) DIMENSIONS, dd (optional, use IN. or FT, default 13 IN.) (affects all x and y values)

(6) (Use POINTS or RECTANGLE or CIRCLE; the entire cross section must be in the first quadrant)

(1) POINTS, np (np is no. of points, 99 max.)
x_1, y_1, x_2, y_2,...,..., x_{np}, y_{np} (use as many lines as needed, keep the concrete to the right)

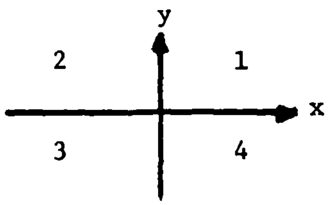
(2) RECTANGLE, x_1, y_1, x_2, y_2 (points 1 and 2 are diagonally opposite, sides are parallel to axes.)

(3) CIRCLE, $r_{outside}$, r_{void}, x_{center}, y_{center}

(7) REINFORCE, nrows
rbar, abar, x_1, y_1, x_2, y_2 (one line thus for each row, nrows rows)

(8) A77

(9) (repeat this set as many times as there are load cases)
LOAD, casename, nlines
m_x, m_y, force, x_{force}, y_{force} (moments are kip-ft, force is feet)
(+m_x yields tension in quadrants 1 and 2)
(+m_y yields tension in quadrants 2 and 3)
(+force is tension)
(one line thus for each loading, use nlines lines)



(10) (Start new problems here, beginning with MEMBER or SECTION.)

(11) EXIT (Last line in data file)

Starting a Program Run

General procedure

32. Prepare data file. See paragraph 16 for general rules for the data file. Files may be prepared with or without line numbers. Line numbered files can be prepared without using the timesharing text editor and are preferred by many users. Note that from one to three blanks may be used to separate the line number from the data on the line.

Program control

33. The underlined responses are to be entered by the user.

```
INPUT FILE NAME (8 CHAR MAX)
= datafile
INPUT 1 IF FILE HAS LINE NUMBERS, Ø IF NOT
= 1
```

Interpretation of Output

Message page

34. The second page will contain any of several error messages, two of which are

*** YOU HAVE MORE THAN 99 CONCRETE POINTS ***

*** YOU HAVE MORE THAN 30 ROWS OF STEEL***

Either of these self-explanatory messages will be followed by a program termination.

35. File System Error. If the program stops abruptly and you get a system prompt shortly after you answer the question about data file line numbers, it means that the file was busy or that the file name was in error.

36. Computer System Errors. Such errors will be printed here if they occur before processing the "A77" name word.

37. None of the above. If none of the above messages apply, the message page will be blank.

Figure 1 data input check

38. This page displays confirmation of data sections up to A77. A multiple-problem data file will produce one such page for each new problem. Printout Figures 1, applying to each sample problem in this text, are found on pages 25, 31, 37, and 43.

a. The user's name line of the data file will be printed in the upper left corner, after the words "DATA PREPARED BY--".

b. The MEMBER and SECTION data sections will be printed in the box in the lower right corner.

c. The date the problem was processed will be printed in the upper right corner.

d. Reinforcement data will be printed and plotted to scale, if entered. Row designators are printed at each row of bars. Dotted lines connect bars in a row.

e. Concrete outline data will be printed and plotted to scale.

Figure 2 strain analysis and interaction diagram

39. There will be one such page for each LOAD data section. The first LOAD data section will produce Figure 2.1, the second one will produce Figure 2.2, etc. The Figures 2.1 and 2.2 for each problem will be found in the text in that order on pages 26 and 27, 32 and 33, 38 and 39, and 44 and 45. Each such page may take from 15 min to an hour to compute and plot, depending on the total computer system work load.

40. The MEMBER and SECTION data sections will be printed in the box in the lower right corner of the page. The load case name will be printed in the upper right corner of the page, after the word "LOAD" in the second line.

41. The REQUIRED STRENGTH (U) information block on the right side shows

a. The summation of all the load sets combined into one loading.

b. The design strength parameters used:

PHI = capacity reduction factor from ACI 318-77.

= 0.9 for flexure, 0.7 for axial load, transitioning as described in ACI 318-77 Section 10.3.3.

e_{max} = design allowable strain e_m, at the extreme concrete compression fiber = 0.003.

(paragraph 13 of this User's Guide.)

c. The percentage of the ratio of actual to balanced tensile reinforcement, as a measure of beam ductility. This is printed only when the value is significantly large.

42. The right side of the figure, below the REQUIRED STRENGTH information block, shows

a. The ϕ (capacity reduction) factor for the particular ratio of axial to flexural stress.

b. A small-scale plot of the cross section, showing

(1) Point of application of applied axial force.

(2) Neutral axis (dotted line), if inside the cross section.

(3) Point of maximum actual required strength compressive strain (* symbol), if the section is not stressed beyond the "design strength" curve, and its numeric value.

(4) Reinforcing bar (if section is reinforced) with maximum tensile strain (+ symbol) and its numeric value.

c. A plot of actual required strength (solid line) versus balanced design strength (dotted line) strains, if the required strength does not exceed the design strength curve in the interaction diagram.

43. Interaction diagram on left side of figure. This is for the orientation shown for the neutral axis, which is based on the load case ratio of M(x)/M(y) .

a. Nomenclature of diagram:

(1) "NOMINAL AXIAL FORCE STRENGTH." This is the axial force capacity of the section, from ACI 318-83 Section 10.3.5. The "nominal strength" curve is truncated at this value and the "design strength" curve is truncated at ϕ (PHI) times this value.

(2) "NOMINAL STRENGTH." This curve is the theoretical outside limit of ultimate strength when the capacity reduction factor ϕ (PHI) is not included (paragraph 43-b).

(3) "DESIGN STRENGTH." This curve is the design outside limit of strength when the capacity reduction factor is included in the equations for capacity to sustain factored loads (paragraph 43-b).

(4) "REQUIRED STRENGTH." This is the point where the load case combination of factored forces and moments falls in the plot. The section is considered to be strong enough if this point falls on or inside the "design strength" curve, without regard to beam ductility requirements.

b. Interpretation of diagram:

(1) The nominal strength curve is a plot of the moments and axial loads which, when acting together, cause the concrete section to fail. This curve is comprised of three distinctly different regions. Those M(x)'s and P(x)'s which make up that portion of the curve below the bold asterisk would fail the section by yielding of the tensile reinforcement. Those M(x)'s and P(x)'s which fall on that portion of the curve above the bold asterisk would fail the section by crushing of concrete. The horizontal line at the upper portion of the diagram represents the upper limit of the compressive strength of the section allowed by the ACI code.

(2) As discussed above, the nominal strength curve represents a theoretical failure strength of the section. In order to allow for some unknowns in construction which could lessen the strength of the section, the nominal strength must be reduced by a strength reduction factor called, ϕ . Therefore, the design curve is simply the nominal strength reduced by a ϕ factor. This line then represents the limit of the strength of a section for use in design. The concrete section is satisfactory for any M(x) and P(x) which falls on or inside the design strength line, without regard for minimum ductility requirements.

(3) The point defined on the diagram as the Required Strength is the user's input value of the total M(y) , M(x) , and P acting on the section. This point must fall in the admissible region for the section to be considered satisfactory.

Sample Problems

44. These problems illustrate the flexibility of the program and demonstrate its validity. The first two sample problems are taken from the Portland Cement Association's (PCA) ACI 318-77 Building Code Requirements.* They are presented to verify the computer solutions. The number in the "SECTION" block in the data and output figures corresponds to the example number in the PCA's Book.

Sample problem 1

45. This problem, called Example 3.1 in the PCA publication, is a doubly reinforced continuous beam at midspan. The expected strength is changed from the one referenced, by using hypothetical bar areas to yield the required steel instead of the area furnished by standard bar sizes:

$$\text{Top reinforcement} = \frac{5.35}{4} = 1.3375 \text{ sq in./bar}$$

$$\text{Bottom reinforcement} = \frac{2.73}{4} = 0.6825 \text{ sq in./bar}$$

The difference in shape of stress block between the rectangular approximation in the ACI code and the trapezoidal approximation in the program leads to a slightly smaller moment capacity being indicated by the program. In the sample run shown on the following pages, the book example loading is shown in

---

* Portland Cement Association. 1978. Notes on ACI 318-77 Building Code Requirements for Reinforced Concrete with Design Applications.

Figure 2.1 of the printout; the load value of 196.5 shown in Figure 2.2 was determined by successive trials that are not shown. The figures are found on pages 26 and 27.

$$
\begin{array}{rl}
\text{Referenced example value} = & 197.0 \text{ ft-kip} \\
\text{Program value} = & \underline{196.5} \\
\text{Difference} & \;\;0.5 \;\; = 3 \text{ percent difference}
\end{array}
$$

Input File for Sample Problem 1

```
*LIST X61D1

1000 PCA Notes on ACI 318-77
1010 MEMBER, PLAIN BM.
1020 SECTION, Ex. 3.1
1030 MATERIALS, 4000, 60000
1040 RECTANGLE, 0, 0, 16, 20
1050 REINF, 2
1055 4, 1.3375, 2.5, 17.5, 13.5, 17.5
1060 4, 0.6825, 2.5, 2.5, 13.5, 2.5
1070 A77
2000 LOAD, + MOMENT, 1
2010 -197, 0, 0, 0, 0
3000 LOAD, ADJUSTED, 1
3010 -196.5, 0, 0, 0, 0
4000 EXIT
```

Output for Sample Problem 1

```
*FRN WESLIB/CORPS/X0061,R
******************************
* CORPS PROGRAM #  X0061     *
*       VERSION # 83/10/01   *
******************************

PROGRAM X0061 -- 713-F3-R0 061 -- SEP 83
CONCRETE GENERAL STRENGTH INVESTIGATION

INPUT FILE NAME (7 CHAR MAX)
=X61D1

INPUT 1 IF FILE HAS LINE NUMBERS, 0 IF NOT
=1
```

FIG. 1. DATA INPUT CHECK

02/07/84

PROGRAM X0061 -- REL 1.3 --- SEP 83
BIAXIAL BENDING ANALYSIS (STRENGTH THEORY)

DATA PREPARED BY -- PCA Notes on ACI 318-77

COORDINATES OF SECTION POINTS

POINT	X	Y	POINT	X	Y
1	0.	0.	4	16.000	0.
2	0.	20.000	5	0.	0.
3	16.000	20.000			

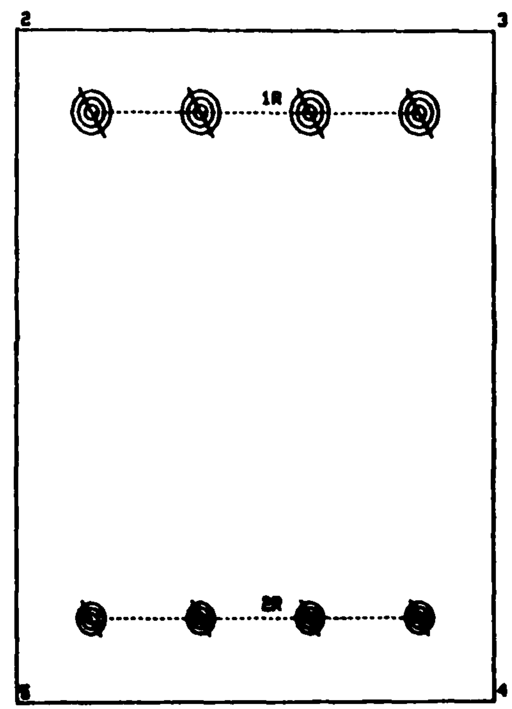
REINFORCEMENT

ROW	NO.	AREA (IN2)	X1 (IN)	Y1 (IN)	X2 (IN)	Y2 (IN)
1R	4	1.34	2.500	17.500	13.500	17.500
2R	4	0.68	2.500	2.500	13.500	2.500

MATERIAL CONSTANTS

F'C = 4000. PSI
FY = 60000. PSI
E(CONCRETE) = 3604997. PSI
E(STEEL) = 29000000. PSI

(TIED LATERAL REINFORCEMENT)

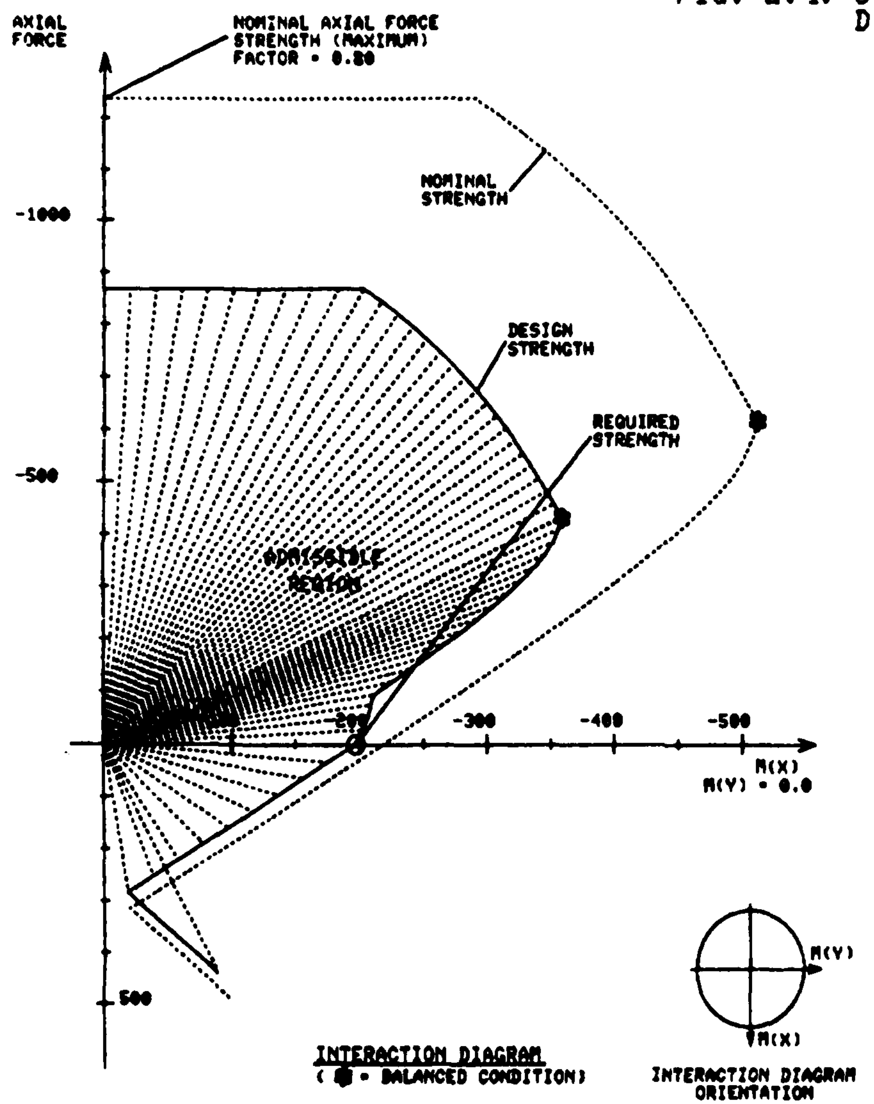


AREA OF REINFORCEMENT / GROSS AREA = 0.085

MEMBER PLAIN BM. SECTION Ex. 3.1

FIG. 2. 1. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD + MOMENT

08/10/84



REQUIRED STRENGTH (U)
(REFERENCED TO XC,YC)

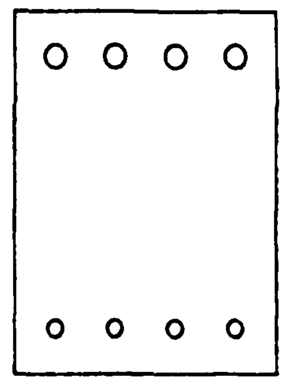
P(U) = 0. KIPS
M(UX)= -197.000 KIP-FT
M(UY)= 0. KIP-FT

(XC,YC)= 8.000 10.000

ACI 318-77 STANDARD-
PHI FROM ACI CODE
e MAX = 0.00300
FV NOT LIMITED

PERCENTAGE OF BALANCED REINFORCEMENT = 21.05 %

STRAINS AT U/Φ (Φ =0.90)
(NEUTRAL AXIS = ...)



INADMISSIBLE LOAD CASE
(REQUIRED STRENGTH EXCEEDS DESIGN STRENGTH)

MEMBER PLAIN BM. SECTION EX. 3.1

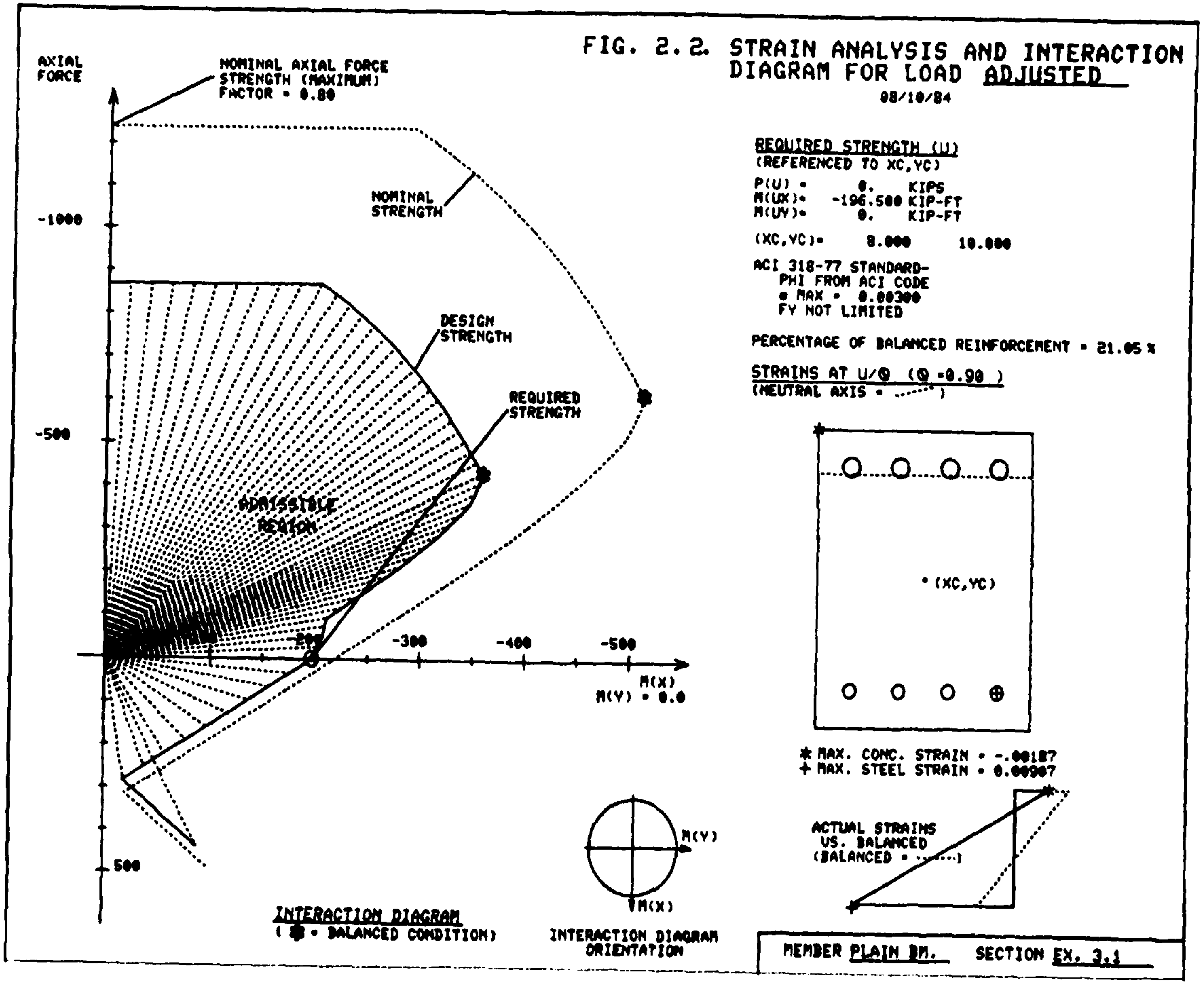


FIG. 2.2. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD ADJUSTED

Sample problem 2

46. Corresponding to Example 10.3 in the PCA publication, this problem is a tied rectangular column with combined axial load and uniaxial bending. As in the previous example, the theoretical minimum reinforcing (1.68 sq in./bar) is used instead of the ASTM Standard #14 (2.25 sq in./bar). The sample run on the following pages shows the book example load case in Figure 2.1 and a slightly reduced loading that the program selected for the capacity in Figure 2.2. Pages 32 and 33 show Figures 2.1 and 2.2.

	P_u	M_u
Reference example value =	898 K	276 lK
Program values =	896	275
Difference	2	1

Input File for Sample Problem 2

```
*LIST X61D2

1000 PCA notes on ACI 318-77
1100 MEMBER, COLUMN
1200 SECTION, Ex. 10.3
1300 MATERIALS, 5000.0, 60000.0
1400 RECTANGLE, 0, 0, 14.0, 24.0
2000 REINF, 2
2100 2, 1.68, 2.375, 21.625, 11.625, 21.625
2200 2, 1.68, 2.375,  2.375, 11.625, 2.375
3000 A77
4000 LOAD, EXAMPLE, 1
4010 -276.0, 0, -898.0, 7.0, 12.0
5000 LOAD, ADJUSTED, 1
5010 -275.0, 0, -896.0, 7.0, 12.0
9000 EXIT
```

Output for Sample Problem 2

```
*FRN WESLIB/CORPS/X0061,R

PROGRAM X0061 -- 713-F3-R0 061 -- SEP 83
CONCRETE GENERAL STRENGTH INVESTIGATION

INPUT FILE NAME (7 CHAR MAX)
=X61D2

INPUT 1 IF FILE HAS LINE NUMBERS, 0 IF NOT
=1
```

(With no errors, the second page
of the printout is blank.)

PROGRAM X0061 -- REL 1.3 --- SEP 83
BIAXIAL BENDING ANALYSIS (STRENGTH THEORY)

DATA PREPARED BY -- PCA NOTES ON ACI 318-77

COORDINATES OF SECTION POINTS

POINT	X	Y	POINT	X	Y
1	0.	0.	4	14.000	0.
2	0.	24.000	5	0.	0.
3	14.000	24.000			

REINFORCEMENT

ROW	NO.	AREA (IN2)	X1 (IN)	Y1 (IN)	X2 (IN)	Y2 (IN)
1R	2	1.68	2.375	21.625	11.625	21.625
2R	2	1.68	2.375	2.375	11.625	2.375

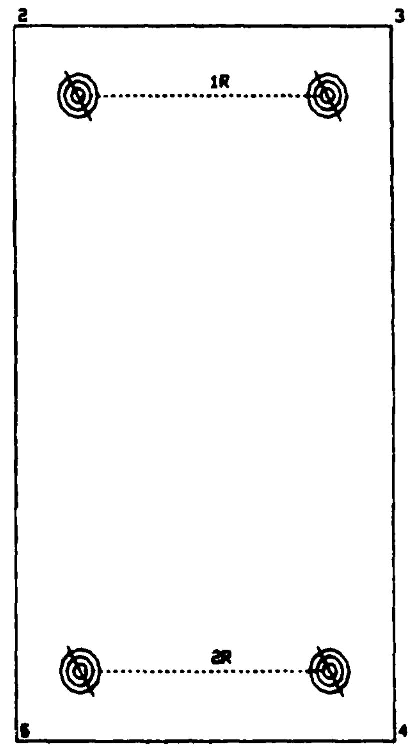
MATERIAL CONSTANTS

F'C = 5000. PSI
FY = 60000. PSI
E(CONCRETE) = 4030509. PSI
E(STEEL) = 29000000. PSI

(TIED LATERAL REINFORCEMENT)

FIG. 1. DATA INPUT CHECK

08/10/84



AREA OF REINFORCEMENT / GROSS AREA = 0.020

MEMBER COLUMN SECTION EX. 10.3

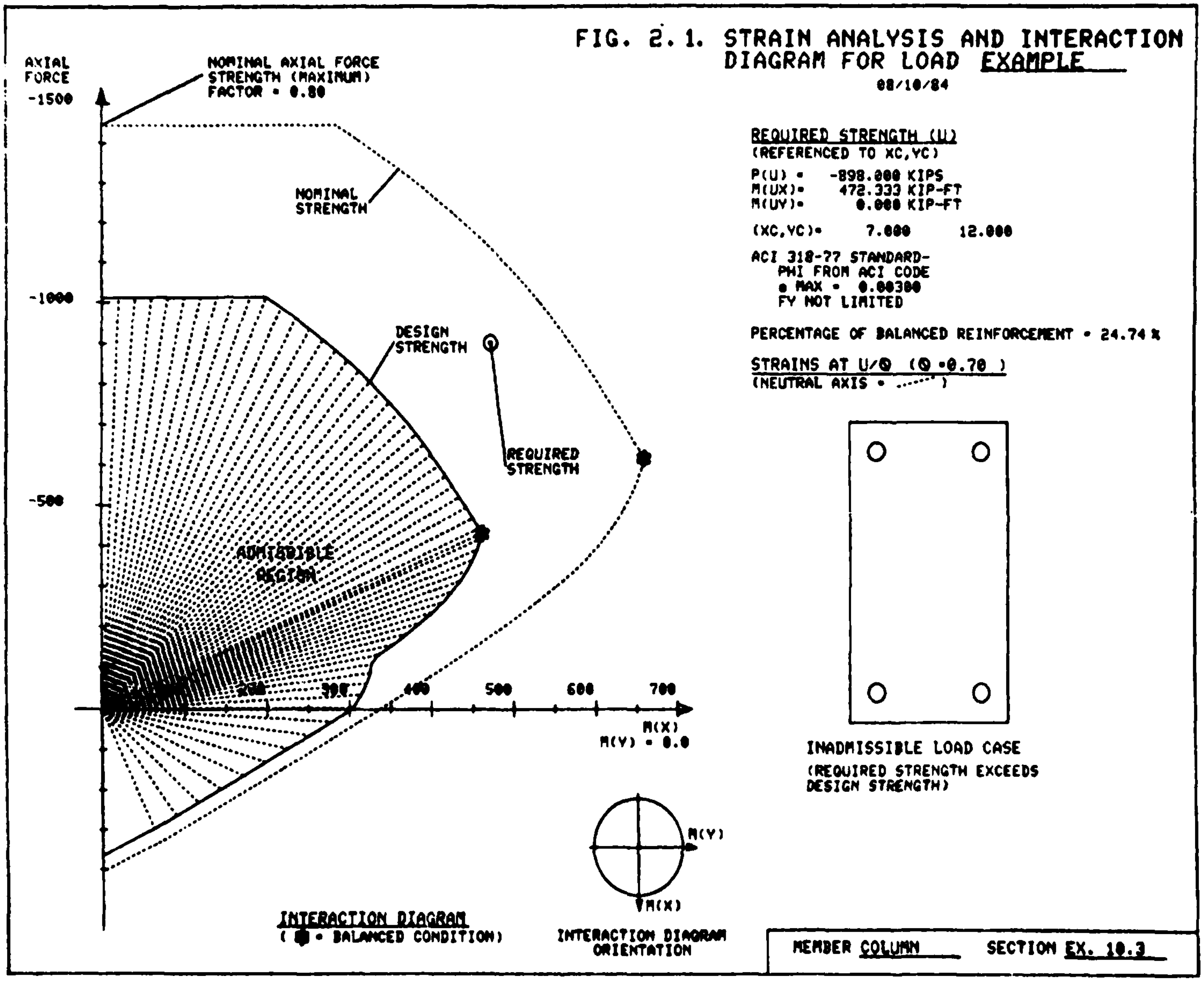
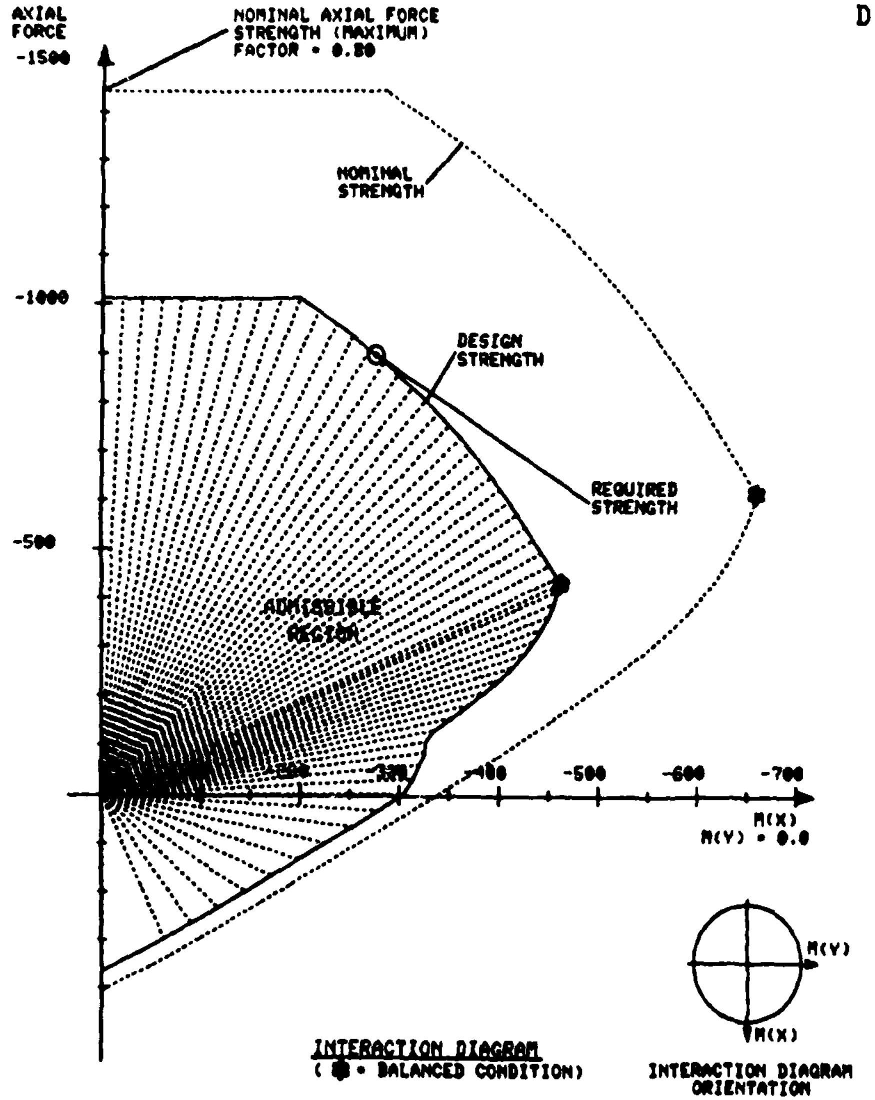


FIG. 2.1. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD EXAMPLE

FIG. 2.2. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD ADJUSTED

08/10/84



REQUIRED STRENGTH (U)
(REFERENCED TO XC,YC)

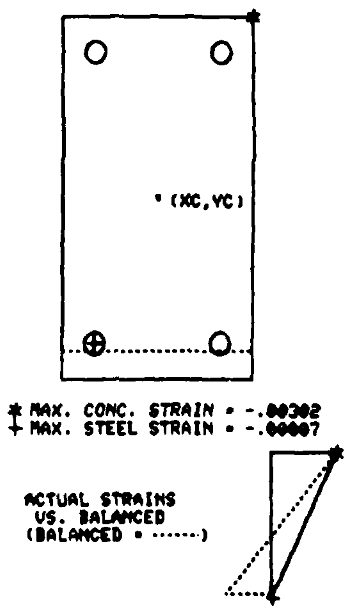
P(U) = -896.000 KIPS
M(UX)= -275.000 KIP-FT
M(UY)= -0.000 KIP-FT

(XC,YC)= 7.000 12.000

ACI 318-77 STANDARD-
PHI FROM ACI CODE
e MAX = 0.00300
FY NOT LIMITED

PERCENTAGE OF BALANCED REINFORCEMENT = 24.73 %

STRAINS AT U/Φ (Φ = 0.70)
(NEUTRAL AXIS = ...)



MEMBER COLUMN SECTION EX. 10.3

Sample problem 3
<u>without reinforcing steel</u>

47. This sample is derived from the sample problem 2 by removing the reinforcing steel and reducing the applied loading until the section is adequate. Figure 2.1 of the printout shows the sample problem 2 loading; Figure 2.2 shows a loading that was reduced, loading a constant eccentricity, until the section was adequate. Figures 2.1 and 2.2 are found on pages 38 and 39. Problems without reinforcing may cause divide check messages to be displayed briefly, but these messages should be ignored.

Input File for Sample Problem 3

```
*LIST X61D3

1000 UNREINFORCED SECTION
1100 MEMBER, COLUMN
1200 SECTION, Ex. 10.3
1300 MATERIALS, 5000.0, 60000.0
1400 RECTANGLE, 0, 0, 14.0, 24.0
3000 A77
4000 LOAD, EX10.3, 1
4010 -275.0, 0, -896.0, 7.0, 12.0
4100 LOAD, ADJUSTED, 1
4110 -220.0, 0, -640.0, 7.0, 12.0
9000 EXIT
```

Output for Sample Problem 3

```
*FRN WESLIB/CORPS/X0061,R

PROGRAM X0061 -- 713-F3-R0 061 -- SEP 83
CONCRETE GENERAL STRENGTH INVESTIGATION

INPUT FILE NAME (7 CHAR MAX)
=X61D3

INPUT 1 IF FILE HAS LINE NUMBERS, 0 IF NOT
=1
```

(With no errors, the second page
of the printout is blank.)

FIG. 1. DATA INPUT CHECK

02/08/84

PROGRAM X0061 -- REL 1.3 --- SEP 83
BIAXIAL BENDING ANALYSIS (STRENGTH THEORY)

DATA PREPARED BY -- UNREINFORCED SECTION

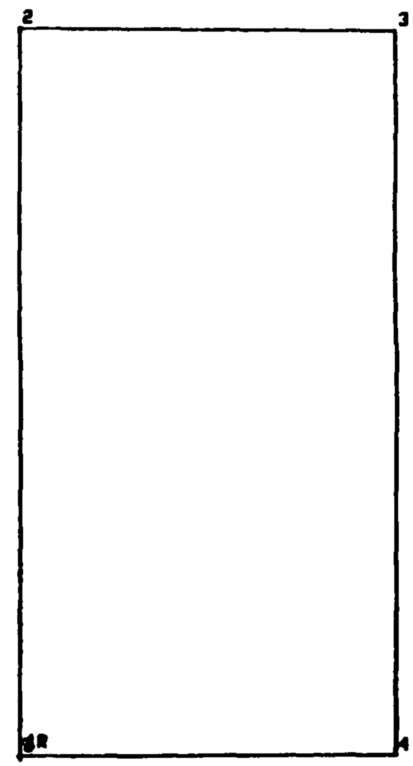
COORDINATES OF SECTION POINTS

POINT	X	Y	POINT	X	Y
1	0.	0.	4	14.000	0.
2	0.	24.000	5	0.	0.
3	14.000	24.000			

MATERIAL CONSTANTS

F'C = 5000. PSI
FY = 60000. PSI
E(CONCRETE) = 4030509. PSI
E(STEEL) = 29000000. PSI

(TIED LATERAL REINFORCEMENT)



AREA OF REINFORCEMENT / GROSS AREA = 0.

MEMBER COLUMN SECTION Ex. 10.3

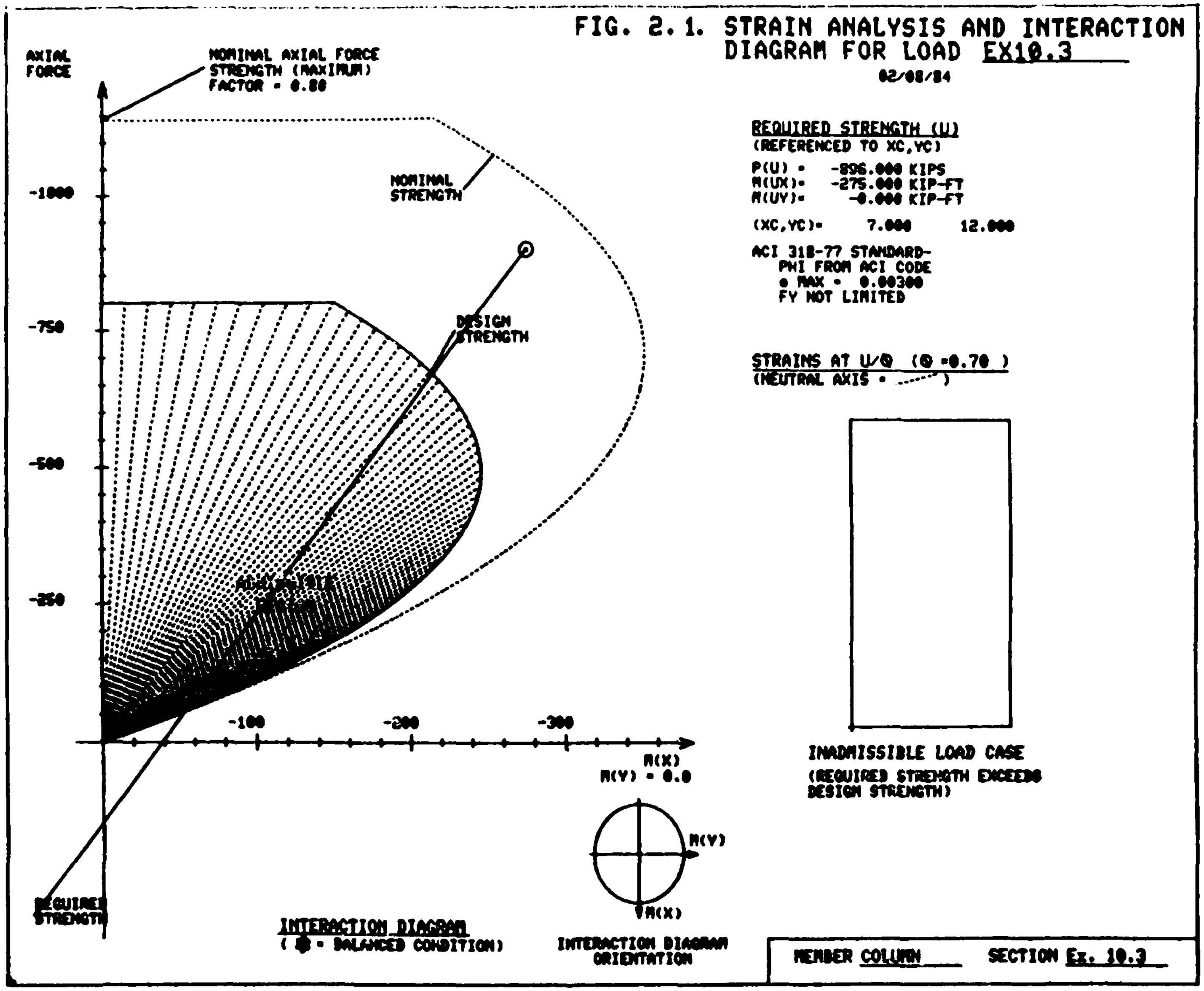


FIG. 2.1. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD EX10.3

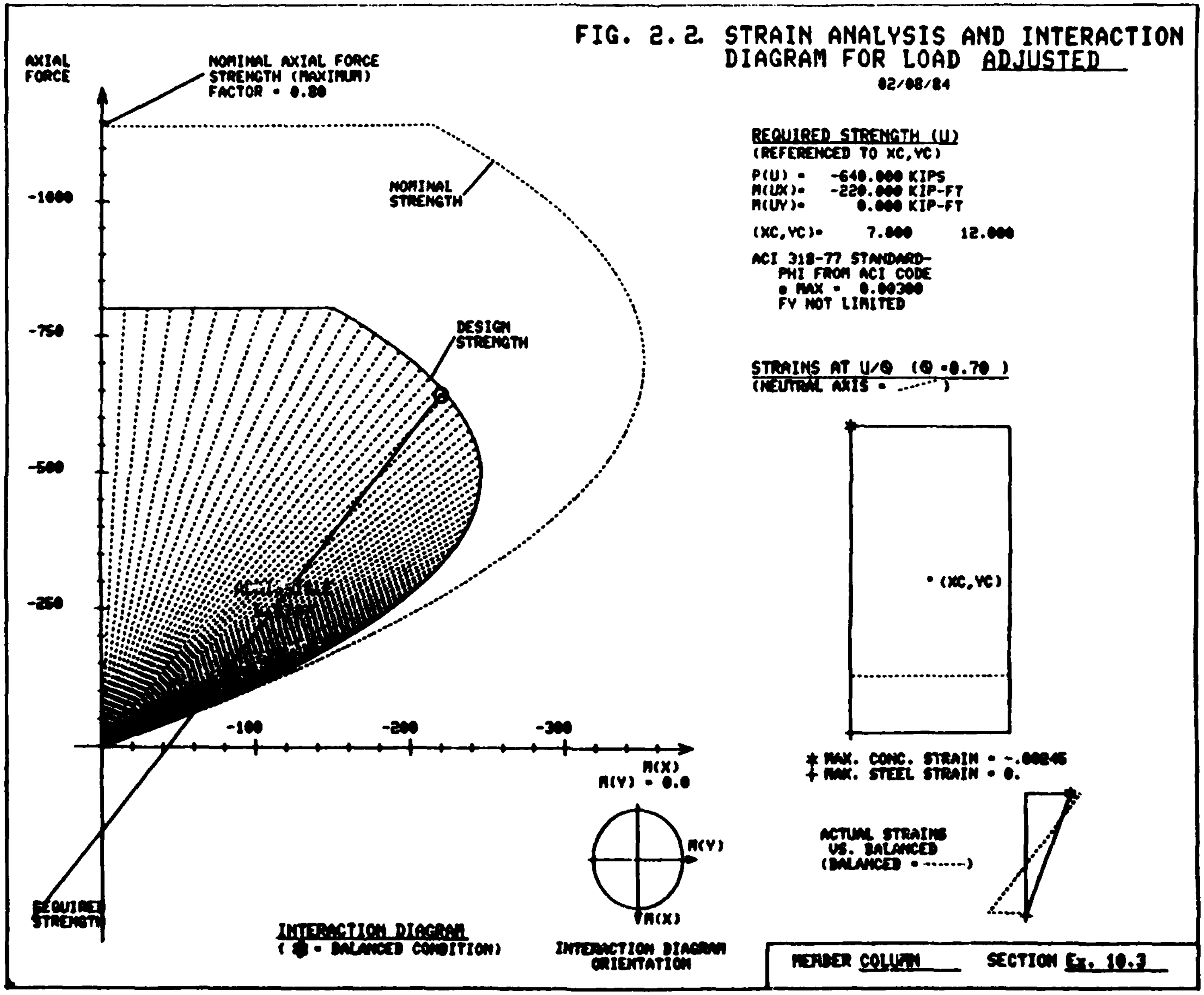


FIG. 2.2. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD ADJUSTED

Sample problem 4 complex
shape and biaxial flexure analysis

48. This problem, taken from the USBR User's Guide, is included to show an analysis of a complex shape with biaxial flexure. Note the use of the POINTS data section rather than the simplified RECTANGLE data-section input. The use of SOLVE instead of A77 is a USBR standard split into the A77 and USE options. The following pages 41 through 45 are included as a part of this problem.

Input File for Sample Problem 4

```
*LIST X61D4

1000 MICHAEL D. DAVISTER
1010 MEMBER,A1-B1XYZ33
1020 SECTION,A1234-ERT4
1030 MATERIALS,4000,60000
1040 DIMENSION,IN
1050 POINTS,19
1060 0,0,0,18,12,18,12,36,0,36,0,48
1070 36,48,36,36,24,36,24,18,36,18,36,0
1080 30,0,30,12,6,12,6,6,30,6,30,0,0,0
1090 REIN,8
1100 6,1.56,3,3,33,3
1110 6,1.56,3,45,33,45
1120 1,1,15,15,15,39
1130 1,1,21,15,21,39
1140 1,1,3,15,0,0
1150 1,1,3,39,0,0
1160 1,1,33,15,0,0
1170 1,1,33,39,0,0
1180 SOLVE
1190 LOAD,DEAD+LIVE,1
1200 -1200,900,-1000,18,24.75
1210 LOAD,DEAD+L+ERQ,1
1220 1500,1500,-1000,18,24.75
1230 EXIT
```

Output for Sample Problem 4

```
*FRN UESLIB/CORPS/X0061,R

PROGRAM X0061 -- 713-F3-R0 061 -- SEP 83
CONCRETE GENERAL STRENGTH INVESTIGATION

INPUT FILE NAME (7 CHAR MAX)
*X61D4


INPUT 1 IF FILE HAS LINE NUMBERS, 0 IF NO
T
*1
```

```
*** SOLVE COMMAND HAS BEEN REPLACED WITH-
    A77 TO USE ACI 318-77 CODE (USBR PROG. G4BIAXU)
    USE TO FURNISH YOUR OWN VALUES FOR PARAMETERS
        IN FORMAT--
          USE, PHI, ● MAX, EC, RK1, PMAXF
        WHERE PHI = YOUR VALUE OF STRENGTH REDUCTION FACTOR,
                    REGARDLESS OF ECCENTRCITY
            ● MAX = MAX. STRAIN IN CONCRETE
                    (ACI 318 USES 0.003)
               EC = CONCRETE MODULUS OF ELASTICITY (PSI)
              RK1 = MAX. CONC. STRESS / ULT. STRENGTH
                    (ACI 318 USES 0.85)
            PMAXF = COLUMN FACTOR ON AXIAL STRENGTH
                    (ACI 318 USES 0.8 FOR TIED COLUMNS)
        (See also note 1c below for SECTION=PMAXF = 1.
        option to cancel PMAXF effect on axial strength.)

    PROGRAM CONTINUES WITH A77 OPTIONS.

FOR ALL VERSIONS OF THE SOLVE COMMAND, REMEMBER THAT--
        1. These factors are always included in the
           axial force capacity (ACI 318-77 paragraphs)
             a. 10.3.5.1 (SPIRAL) factor = 0.85
             b. 10.3.5.2 (TIED)   factor = 0.8
             c. (but factor = 1 if SECTION = 'PMAXF = 1.')
        2. ACI 318-77 paragraphs that are NOT included-
             a. 10.3.5.3 (0.75 factor for ductile failure)
             b. 10.10 (axial capacity slenderness limit)
        3. Stress block is product of these factors-
             a. Max concrete stress = 0.85 * Fc'
             b. Depth as determined for equilibrium
        4. PHI strength reduction factor is from ACI 318-77,
           unless the USE command is used to define a value.

CALL W. A. PRICE, telephone 601/634-3645
( FTS 542-3645 ) FOR ADDITIONAL INFORMATION.
```

(The second sheet contained this message because "SOLVE" was used in line 1180 instead of "A77.")

FIG. 1. DATA INPUT CHECK

08/10/84

PROGRAM X0061 -- REL 1.3 --- SEP 83
BIAXIAL BENDING ANALYSIS (STRENGTH THEORY)

DATA PREPARED BY -- MICHAEL D. DAVISTER

COORDINATES OF SECTION POINTS (INCHES)

POINT	X	Y	POINT	X	Y
1	0.	0.	11	36.000	18.000
2	0.	18.000	12	36.000	0.
3	12.000	18.000	13	30.000	0.
4	12.000	36.000	14	30.000	12.000
5	0.	36.000	15	6.000	12.000
6	0.	48.000	16	6.000	6.000
7	38.000	48.000	17	30.000	6.000
8	36.000	36.000	18	30.000	0.
9	24.000	36.000	19	0.	0.
10	24.000	18.000			

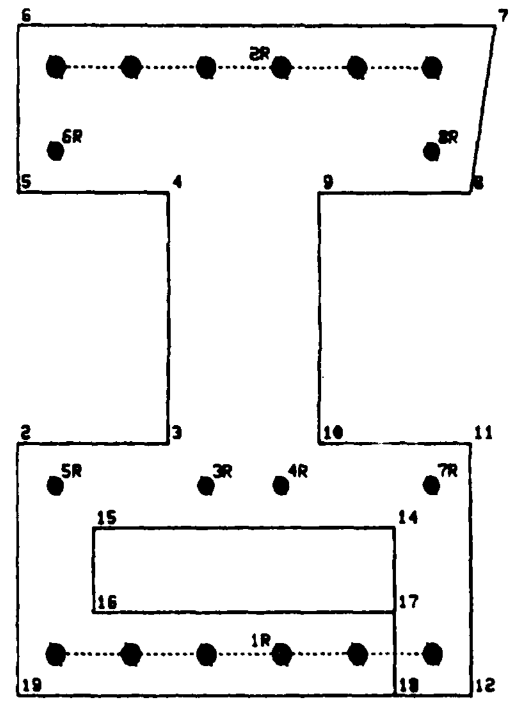
REINFORCEMENT

ROW	NO.	AREA (IN2)	X1 (IN)	Y1 (IN)	X2 (IN)	Y2 (IN)
1R	6	1.56	3.000	3.000	33.000	3.000
2R	6	1.56	3.000	45.000	33.000	45.000
3R	1	1.00	15.000	15.000		
4R	1	1.00	21.000	15.000		
5R	1	1.00	3.000	15.000		
6R	1	1.00	3.000	39.000		
7R	1	1.00	33.000	15.000		
8R	1	1.00	33.000	39.000		

MATERIAL CONSTANTS

F'C = 4000. PSI
FY = 60000. PSI
E(CONCRETE) = 3604997. PSI
E(STEEL) = 29000000. PSI

(TIED LATERAL REINFORCEMENT)



AREA OF REINFORCEMENT / GROSS AREA = 0.021

MEMBER A1-B1XYZ33 SECTION A1234-ERT4

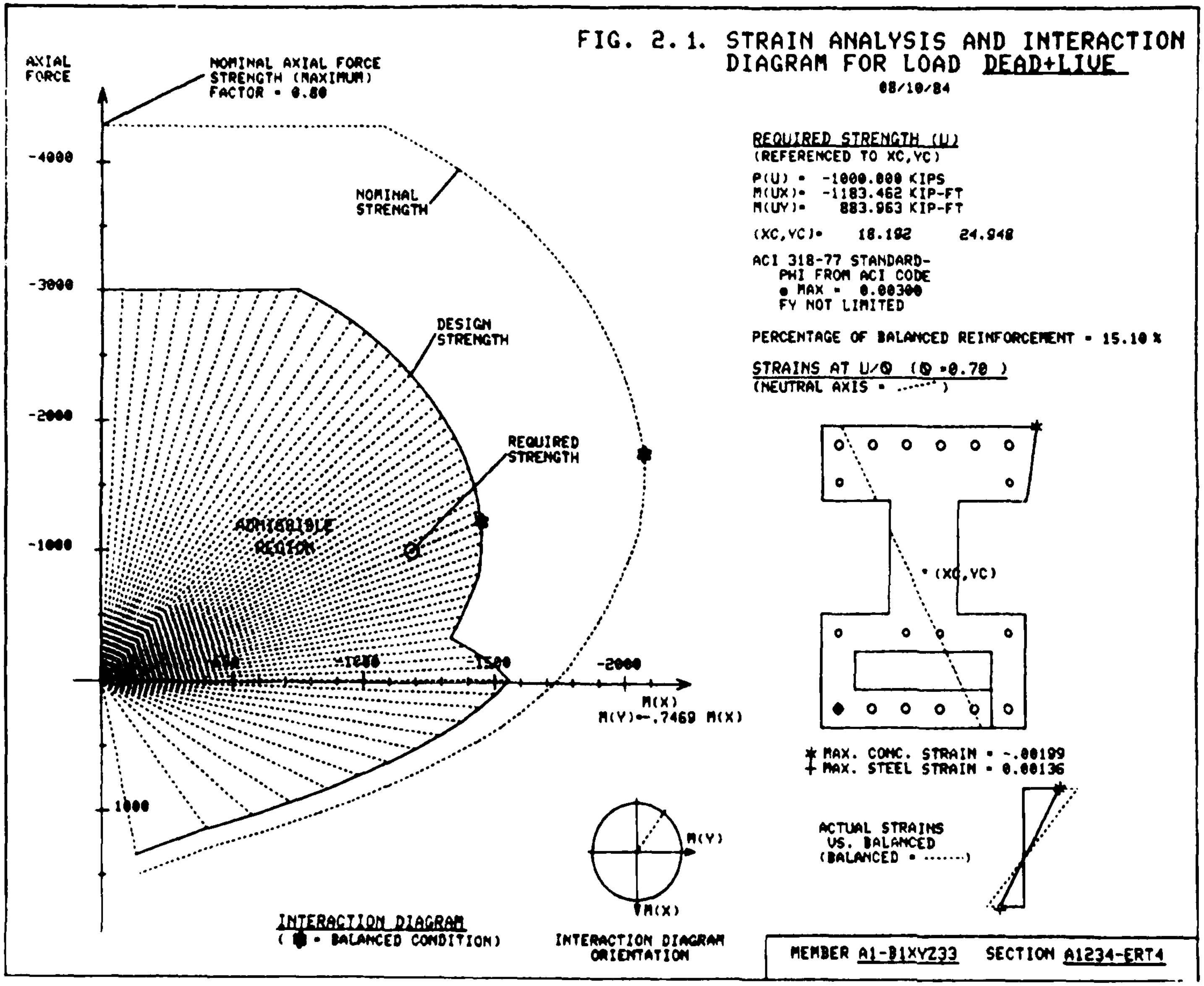


FIG. 2.1. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD DEAD+LIVE

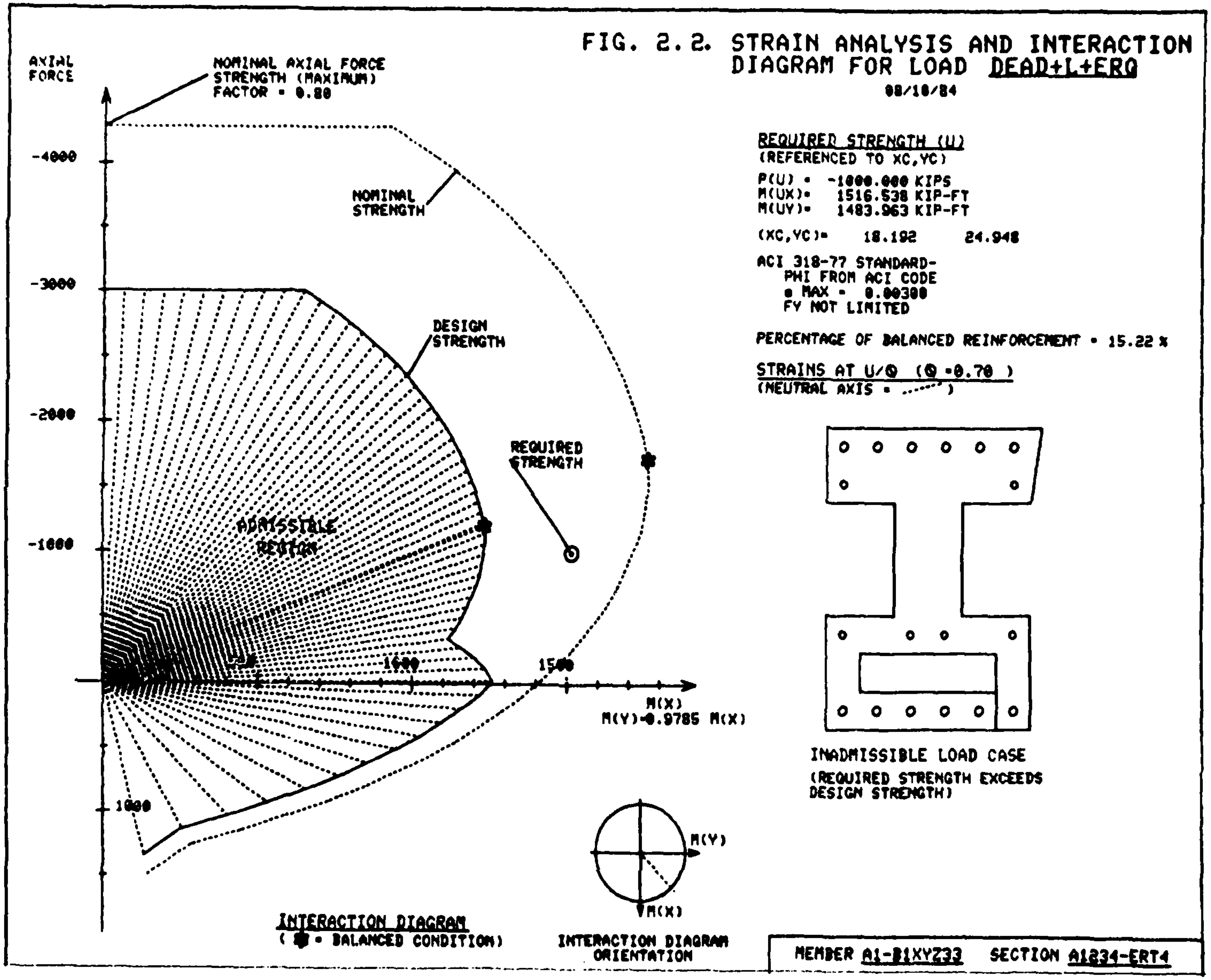


FIG. 2.2. STRAIN ANALYSIS AND INTERACTION DIAGRAM FOR LOAD DEAD+L+ERQ

END

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